PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-230002

(43)Date of publication of application : 29.08.1995

(51)Int.Cl. G02B 5/02
G02B 5/04
G02F 1/1335

(21)Application number : 06-020669

(22)Date of filing : 17.02.1994

(71)Applicant : MITSUBISHI RAYON CO LTD

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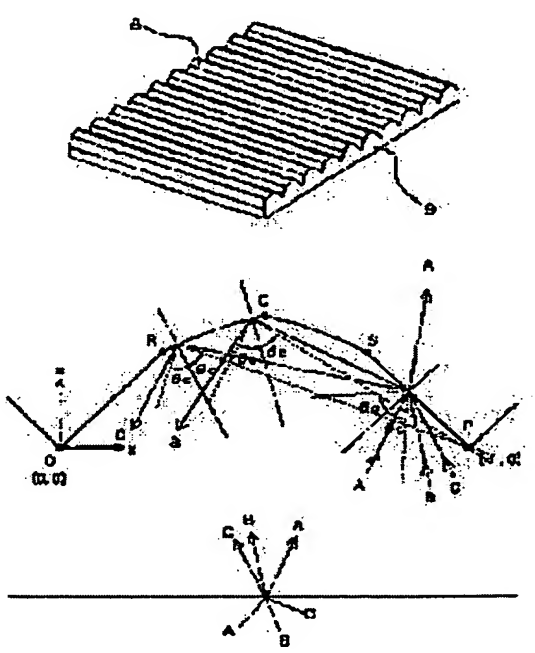
(54) LUMINANCE IMPROVED TRANSPARENT SHEET

(57)Abstract:

PURPOSE: To obtain a directional back light which has its directivity improved and is usable for a liquid crystal panel with a wide visual field angle without spoiling the front luminance improvement effect by dividing both slanting surfaces of a conventional prism sheet into two and altering the surfaces containing the vertical angle into gentry slanting convex curved columnar surfaces.



CONSTITUTION: The transparent sheet 9 is formed by arraying many shape units 8, each formed by connecting two convex curved columnar surfaces having generating lines parallel to each other in right-left symmetrical relation at right angles to the generating lines, on one surface, and the respective tangential surfaces and planes cross each other at a ≤180° angle. This transparent sheet 9 transmits or reflects the majority of light as primary transmitted light shown by A or return light shown by B and C, and on secondary transmitted light exits, specially, from a curved columnar surface RQS. A little secondary transmitted light exits from oblique surfaces OR and PS, but the majority of the secondary transmitted light falls on an adjacent shape unit 8 and is absorbed under specific conditions, and part of it is added to the return light. Consequently, almost no light exits at a wide angle.

LEGAL STATUS

[Date of request for examination] 24.07.1997

[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3106050
[Date of registration]	01.09.2000
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

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CLAIMS

[Claim(s)]
[Claim 1] the transparence sheet which is a transparence sheet with which the configuration unit which the flat surface which a bus-bar resembles the music cylindrical surface of two parallel convexes mutually, respectively, and is connected combined with bilateral symmetry was formed in one field together with the direction perpendicular to this bus-bar in large numbers, and is characterized by to make the configuration which each plane of composition and a flat surface cross at the bond part of both this music cylindrical surface, and the bond part of each curved surface and each flat surface at an include angle smaller than 180 degrees.
[Claim 2] The transparence sheet of claim 1 characterized by being formed so that the configuration of this formation unit may fill the following formulas (1) when taking the z-axis in parallel with the normal of the above-mentioned transparence sheet, taking the y-axis in parallel with the bus-bar of the music cylindrical surface of a convex and taking a x axis in the direction of a train of a formation unit.
[Equation 1]

$$\left.\begin{array}{ll} z = A x & (0 \leqq x \leqq B) \\ \dfrac{dz}{dx} = \dfrac{z\tan\phi + (x-p)}{(x-p)\tan\phi - z} & (B < x < T/2) \\ -\dfrac{dz}{dx} = \dfrac{z\tan\phi + (T-x-p)}{(T-x-p)\tan\phi - z} & (T/2 < x < T-B) \\ z = -A(x-T) & (T-B \leqq x \leqq T) \end{array}\right\} \quad \cdots \quad (1)$$

(phi=0.8thetac-1.2thetac, thetac=sin -1 (1/n), and n express the refractive index of a formation unit among a formula.) p=0.8T-1.5T and T express the width of face of a formation unit.
[Claim 3] It is the transparence sheet characterized by being the transparence sheet with which the partial multiple cylindrical surface which four flat surfaces combined with bilateral symmetry was formed in one field together with the direction perpendicular to the bus-bar of this multiple cylindrical surface in large numbers, and ******** of this multiple cylindrical surface making the configuration which crosses at an include angle respectively smaller than 180 degrees.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the technique which raises the transverse-plane brightness of the back light unit used for a liquid crystal display etc. with an optical means.
[0002]
[Description of the Prior Art] In the product on condition of the dc-battery drive of the portable notebook computer equipped with the color liquid crystal display, the portable liquid crystal TV using an electrochromatic display panel or the video one apparatus liquid crystal TV, etc., etc., it has been a failure for a liquid crystal display with large power consumption to develop dc-battery drive time amount in recent years. It considers as the target important [the rate of the power consumption of the back light used for this especially is large, and] when stopping this low develops dc-battery drive time amount and it raises practical use worth of above-mentioned goods.
[0003] Under the present circumstances, in order to stop power consumption, in having reduced the brightness of a back light, a display becomes hard to see and is not desirable. Then, although to improve the optical effectiveness of a back light is desired in order to stop power consumption, without sacrificing brightness, the method of setting the prism sheet 1 which formed the prism train 2 in one side like drawing 9 on the luminescence side 4 of a back light 3 as a means to realize this is put in practical use now. The increment in the transverse-plane brightness by this prism sheet is caused by the following mechanisms.
[0004] The part carries out refraction transparency with a prism sheet, the remainder reflects, and the light from the surface light source is returned to the surface light source. Generally the surface light source of an edge light type like 3 of drawing 9 R> 9 has comparatively low transverse-plane brightness, and since the brightness seen from across has high directivity, directional characteristics are improved so that transverse-plane brightness may increase by refraction by the prism sheet 1. Moreover, although diffuse reflection of the reflected light from the prism sheet 1 is carried out with the diffusion sheet 4 of the luminescence side of the surface light source and the brightness of a luminescence side is made to increase, transverse-plane brightness also increases in connection with this.
[0005]
[Problem(s) to be Solved by the Invention] Drawing 8 is what showed the cross section perpendicular to both the slant faces of the prism of such a prism sheet. The component a for which the beam of light which carried out incidence penetrates a direct prism slant face according to the incident angle (it is henceforth described as the primary transmitted light) The component b which reflects again on another slant face and is returned to an incidence side once reflecting on a prism slant face (it is henceforth described as return light) Once reflecting on a prism slant face, it is about divided into the component c (it is henceforth described as the secondary transmitted light) which penetrates another slant face and comes out in front (although the component further reflected multiply depending on selection of a prism vertical angle also exists, there are usually few the rates). At this time, Component a is a beam of light containing the light which comes out in a transverse plane, i.e., the direction to observe, used in fact, and is an effective beam of light to which diffuse reflection of the component b is carried out with the diffusion sheet of the luminescence side of the surface light source, and the brightness of a luminescence side is made to increase. On the other

hand, Component c is a beam of light which appears in whenever [besides the effective angle of visibility of a liquid crystal panel / wide angle], and is a component which is not helpful.
[0006] Once brightness will fall rapidly if a light (primary transmitted light) bright to the width of face of the angle of visibility around **40 degrees from a transverse plane (in the case of 90 degrees - 100 degrees of vertical angles and about 1.5 to 1.59 refractive index) about the direction where the light from a prism sheet is perpendicular to the ridgeline of prism is emitted as a result and it becomes an angle of visibility beyond it, and it almost becomes zero, brightness increases again with a still bigger angle of visibility (secondary transmitted light). It has a form which narrowed down the include-angle range of an outgoing radiation beam of light as a result, and increased brightness.
[0007] The directivity to which brightness falls in the first place rapidly more than the angle of visibility around 40 degrees becomes a problem here. That with which an improvement progresses and the directivity of a liquid crystal panel indicates sufficiently practical contrast to be with the angle of visibility of 40 degrees or more also in the direction where directivity is narrow is developed in recent years. To such a liquid crystal panel, the fall of the brightness accompanying the increment in an angle of visibility is loose, and to some extent large directivity is wanted to be shown.
[0008] Moreover, the second trouble is existence of the secondary transmitted light which is not helpful, and if this component can be reduced, it can expect much more improvement in efficiency. It is the vertical angle of prism as for that pointed out to USP2,474,317 [0009]
[Equation 2]
180 degree-4 (90 degree-thetac) / m, and ... (m is three or more integers) -- (2 [0010]) It is possible for it to be alike and to choose. Although the secondary transmitted light becomes zero and the effectiveness as the whole is improved by this, the first trouble still described above remains.
[0011] The purpose of this invention is developing an optical sheet with the efficient increment effectiveness in brightness of the highest brightness's having been shown in the direction of a transverse plane, and having had the luminance distribution which falls in the direction beyond a predetermined angle of visibility gently with the increment in an angle of visibility, and having suppressed the above-mentioned generating of the secondary transmitted light.
[0012]
[Means for Solving the Problem] The configuration unit which the flat surface which leads to the music cylindrical surface and each of two convexes with an parallel bus-bar mutually combined with bilateral symmetry the transparence sheet of this invention claim 1 to one field It is the transparence sheet formed together with the direction perpendicular to this bus-bar in large numbers, and each plane of composition and a flat surface are the transparence sheets characterized by making the configuration which crosses at an include angle smaller than 180 degrees in the bond part of this both music cylindrical surface, and the bond part of right-and-left each music cylindrical surface and each flat surface.
[0013] Moreover, the transparence sheet of this invention claim 2 is a transparence sheet of claim 1 characterized by being formed so that the configuration of this formation unit may fill the following formulas (1), when taking the z-axis in parallel with the normal of the above-mentioned transparence sheet, taking the y-axis in parallel with the bus-bar of the music cylindrical surface of a convex and taking a x axis in the direction of a train of a formation unit.
[0014]
[Equation 3]

$$\left.\begin{array}{ll} z = A x & (0 \leqq x \leqq B) \\ \dfrac{dz}{dx} = \dfrac{z\tan\phi + (x-p)}{(x-p)\tan\phi - z} & (B < x < T/2) \\ -\dfrac{dz}{dx} = \dfrac{z\tan\phi + (T-x-p)}{(T-x-p)\tan\phi - z} & (T/2 < x < T-B) \\ z = -A(x-T) & (T-B \leqq x \leqq T) \end{array}\right\} \quad \cdots \quad (1)$$

[0015] In addition, phi=0.8thetac-1.2thetac, thetac=sin -1 (1/n), and n express the refractive index of a formation unit here. Moreover, p=0.8T-1.5T and T express the width of face of a formation unit.
[0016] Furthermore, this invention claim 3 is the transparence sheet with which the partial multiple

cylindrical surface which four flat surfaces combined with bilateral symmetry was formed in one field together with the direction perpendicular to the bus-bar of this multiple cylindrical surface in large numbers, and ******** of this multiple cylindrical surface is a transparence sheet characterized by making the configuration which crosses at an include angle respectively smaller than 180 degrees.

[0017]

[Function] An operation of this invention is explained using drawing below. Drawing 2 is xz sectional view of the transparence sheet of this invention claim 2, and it is the most characteristic and it expresses the case where it is suitable although [explaining the intention of this design] it was phi=thetac of (1) type, and p=T. It is a flat surface between OR and PS here, and the function is the same as that of the slant face of the prism sheet of drawing 8 . It is as follows if expressed with a formula.

[0018]

[Equation 4] z=Ax (between 0 <=x<=B:OR)

z=-A (x-T) (between T-B<=x<=T:PS)

[0019] On the other hand, it is the music cylindrical surface introduced by this invention between RQ and SQ. In the conventional prism sheet of drawing 8 , since that most has emitted from near the vertical angle of prism, in order not to generate this, all the light that changed the configuration near a vertical angle and reflected it on the slant face which counters should just be made to carry out total reflection of the secondary transmitted light in this part. For this reason, with the transparence sheet of drawing 2 , it has always been made to carry out incidence of the light which makes between RQ near a vertical angle, and SQ the music cylindrical surface of a convex, and reaches this part from the slant face which counters to this part by the incident angle more than total reflection angle thetac=sin-1 (1/n). If the straight line which connected each point between RQ from P chooses the beam of light which carries out incidence by the smallest incident angle so that the normal of the field in a tie and the angle to make may become equal to thetac since it is the reflected light from Point P when it sees from each point between RQ, all the reflected lights from other points of a right slant face will be reflected between RQ. When Point O is taken at a zero at this time, the conditions which the coordinate of Point P is set to (T, 0), and the music cylindrical surface RQ fulfills are [0020].

[Equation 5]

$$\frac{dz}{dx} = \frac{z\tan\theta c + (x - T)}{(x - T)\tan\theta c - z} \qquad (B < x < T/2)$$

[0021] It becomes. Numerical integration of this formula is carried out to the basis of the boundary condition which is in agreement at the flat-surface section OR and Point R in fact, and the form of RQ is determined. The same is said of between SQ and it becomes the configuration of bilateral symmetry focusing on x=T/2. Thus, the one whole configuration unit ORQSP will be expressed with (1) type.

[0022] Thus, with the transparence sheet of the cross-section configuration of drawing 2 , B and C become [whether almost all light turns into the primary transmitted light like A, and] return light, and the secondary transmitted light does not come out from the music cylindrical surface RQS especially. Although some secondary transmitted light comes out from slant faces OR and PS, if B of (1) type is chosen suitably, almost all the secondary transmitted light will collide in next configuration, and will be absorbed, and the part will join return light. Most light which appears in whenever [like c of drawing 8 as a result / wide angle] will be lost.

[0023] since the function of the flat surface sections OR and PS of the configuration unit of this transparence sheet be equivalent to the slant face of the conventional prism sheet , the primary transmitted light from here show directivity equivalent to the conventional prism sheet , but when the inclination of the music cylindrical surface RQS be a curved surface more loosely than the flat surface section , the primary transmitted light from this part have the directivity in which brightness carry out include angle change gradually more widely than that of the flat surface sections OR and PS . As a result, the directivity which approaches zero gradually will be shown, making a shoulder on a brightness-include-angle curve so that brightness may not fall rapidly, even if this transparence sheet exceeds the angle of visibility of the conventional prism sheet.

[0024] Although the above explained phi=thetac of (1) type, and the case of p=T, it is possible to change a little the property acquired by adjusting the value of phi and p. For example, the inclination of the music cylindrical surface RQS of phi>thetac or p<T, then a formation unit becomes loose uniformly, and an angle of visibility can extend it more. Therefore, it is effective when you need a large angle of visibility especially. Also in this case, although the secondary transmitted light is not produced, the rate of increase of transverse-plane brightness falls compared with the case of phi=thetac and p=T by having extended the angle of visibility. Since the merit of a transparence sheet will become thin if the rate of increase of transverse-plane brightness becomes not much low, even if phi is large, as for p, it is desirable to a 1.2thetac grade to carry out to to about 0.8T for it to be small.
[0025] On the other hand, it is expectable that phi<thetac or p>T, then an angle of visibility raise more the rate of increase of narrowing and transverse-plane brightness. In this case, although the secondary transmitted light will be produced, it will not become a big problem if reduction of phi or the increments in p are few. However, it is not desirable in order for the secondary transmitted light to increase and to cause the fall of transverse-plane brightness, if not much large p is taken or phi is made small too much. It is desirable that phi presupposes that it is small and p presupposes to to about 1.5T to a 0.8thetac grade for it to be large.
[0026] omega is expressed with the following formulas, when A of (1) type, i.e., the inclination of the flat-surface parts OR and PS, determines the angle-of-visibility range where brightness is the highest and this angle of visibility is set with omega in the above-mentioned transparence sheet.
[0027]
[Equation 6] omega=gamma+sin -1 (nsin-1 (theta c-gamma)) however -- Gamma=tan-1A [0028] The relation of gamma and omega in the case of refractive indexes 1.59 (polycarbonate) and 1.49 (polymethylmethacrylate) was shown in drawing 4 . If gamma is made small, omega becomes large, and although an angle of visibility becomes large, if it is made not much small, it fades and is not desirable [an angle of visibility / the improvement effect of brightness]. Moreover, as a result, as for gamma, it is desirable to choose in 35 degrees - 55 degrees, and while being 40 degrees - 50 degrees is especially the most practical practically preferably [narrowing an angle of visibility not much]. In addition, although brightness falls in the include angle at which the transparence sheet of this invention exceeded omega as mentioned above, by the primary transmitted light from the music cylindrical-surface section RQS, the degree of a fall is loose and the practical angle of visibility has spread more than omega.
[0029] Moreover, B of (1) type has determined the ratio of the flat-surface part in a formation unit, and a music cylindrical-surface part. If it will become close to the conventional prism sheet if B is enlarged not much, and the effectiveness of this invention fades and it is made preferably and small, although improved, if an angle of visibility is made not much small, it falls and is not desirable [an angle of visibility / the improvement effect of brightness]. As for B, it is desirable to choose in 0.2T-0.35T practical.
[0030] It turns out that the improvement in effectiveness by the transparence sheet which has the train of the formation unit of the cross-section configuration shown by (1) formula as mentioned above in one side stopping the directional characteristics which show a gently-sloping brightness change, and the secondary transmitted light is realizable for coincidence. However, this effectiveness is not necessarily restricted, when the cross-section configuration of the music cylindrical surfaces RQ and SQ is expressed with (1) type. the operation which will loosen the operation like drawing 2 , and include-angle change of brightness in other function forms (a cylinder side, secondary music cylindrical surface, etc.) if the configuration of a certain thing is the music cylindrical surface of a convex and the absolute value of a difference of an inclination is smaller than the flat-surface sections OR and PS in the magnitude of effectiveness -- **** -- it is (claim 1).
[0031] Furthermore, even if they are a flat surface like claim 3, if RQ and SQ have the absolute value of the inclination smaller than OR and PS, they have the same operation. Although drawing 3 transposes between RQ of drawing 2 , and SQ to a flat surface A part of light which turns into the secondary transmitted light like B' in the conventional prism configuration shown by the dotted line reflects at a flat surface RQ all over drawing, and it becomes the return light B. A part of secondary transmitted light which goes to whenever [wide angle] like C' in the conventional prism

configuration similarly is more greatly bent at a flat surface RQ like C, it enters per next formation, and this part serves as return light. If the inclination between RQ and SQ is made still smaller, it is also possible to make the secondary transmitted light into zero. However, the brightness angular distribution in these cases is not so loose as the transparence sheet of claim 1 and claim 2, and becomes the characteristic thing which changes with the superposition of the comparatively narrow angular distribution with which the primary transmitted light from the flat-surface sections OR and PS makes, and the comparatively large angular distribution which the primary transmitted light between RQ and SQ makes gradually.

[0032] The perspective view of the transparence sheet of this invention claim 1 and claim 2 was shown in drawing 1 . The pitch T of 0.1mm - about 3mm and a formation unit of the thickness of an actual sheet is 30 micrometers - about 0.5mm. This transparence sheet is used, replacing on the prism sheet 1 of drawing 9 . moreover, the transparence sheet of this invention -- the -- if a formation unit rectangular cross is carried out and two sheets are used in piles, transverse-plane brightness will improve further.

[0033]

[Example] About the refractive index 1.59 (polycarbonate), the continuous line showed to drawing 5 what searched for the configuration of the formation unit of claim 2 at the time of phi=thetac, p=T, A= 1 (45 degrees of inclinations), and B=T/4. This is easily calculable from (1) type with numerical integration. The metal mold which arranged the slot of the cross-section configurations of this drawing and an analog in based on this as T= 50 micrometers was manufactured, the heat press was carried out at the polycarbonate transparence plate with a thickness of 2mm, and the transparence sheet of claim 2 was manufactured. Furthermore, this transparence sheet was put on the luminescence side of the edge light type surface light source, the angular distribution of brightness was measured, and the continuous line showed this result to drawing 8 . The transverse-plane brightness rate of increase at this time was 1.55 times.

[0034] Moreover, like the dotted line of drawing 5 , in the cross-section configuration where each top-most vertices were connected in a straight line, the metal mold which put the slot of the cross-section configurations of this drawing and an analog in order as T= 50 micrometers similarly was manufactured, the heat press was carried out at the polycarbonate transparence plate with a thickness of 2mm, and the transparence sheet of claim 3 was manufactured. The dotted line showed the result of having measured the angular distribution of brightness like [sheet / this / transparence] the point to drawing 8 . The transverse-plane brightness rate of increase at this time was 1.54 times.

[0035] The metal mold of the form where 90 degrees of vertical angles and 112-degree prism were put in order in 50-micrometer pitch as an example of a comparison was manufactured, the heat press was carried out at the polycarbonate transparence plate with a thickness of 2mm, and the conventional prism sheet was manufactured. 112 degrees of vertical angles are set with m= 3 in (2) types here. This transparence sheet was put on the luminescence side of the as same surface light source as the point, and the angular distribution of brightness was measured. The continuous line and the dotted line showed this result to drawing 7 , respectively. In the case of 90 degrees of vertical angles, in the case of 112 degrees [1.52 times and] of vertical angles, the transverse-plane brightness rate of increase at this time was 1.46 times.

[0036] While the transparence sheet of this invention has the transverse-plane brightness rate of increase which is not in the conventional prism sheet inferiority so that clearly if drawing 6 is compared with drawing 7 , it turns out that it had the description it is featureless on the conventional prism sheet that brightness falls gradually with the increment in an angle of visibility, and directivity which employs the engine performance of the liquid crystal panel of a wide-field-of-view angle efficiently is realized. Moreover, although the transparence sheet of claim 2 which introduced the music cylindrical surface is more more desirable in order to realize smoother luminance distribution so that the comparison of the continuous line and dotted line of drawing 6 may show, the direction of claim 3 won and the simplicity of metal mold manufacture should just choose either by any shall be thought more as important between the engine performance and cost.

[0037]

[Effect of the Invention] The transparence sheet of this invention made it possible to realize the back light which has usable directivity in the liquid crystal panel of a wide-field-of-view angle, without

having improved directional characteristics and spoiling the transverse-plane brightness improvement effect by changing into the music cylindrical surface (claim 1, claim 2) or the flat surface (claim 3) of a loose convex of an inclination the field which halves both the slant faces of the conventional prism sheet, respectively, among these makes a vertical angle.

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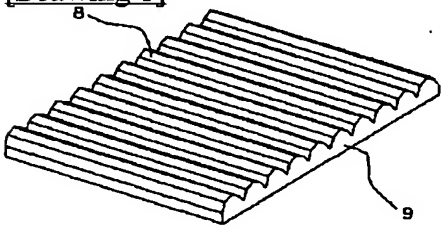
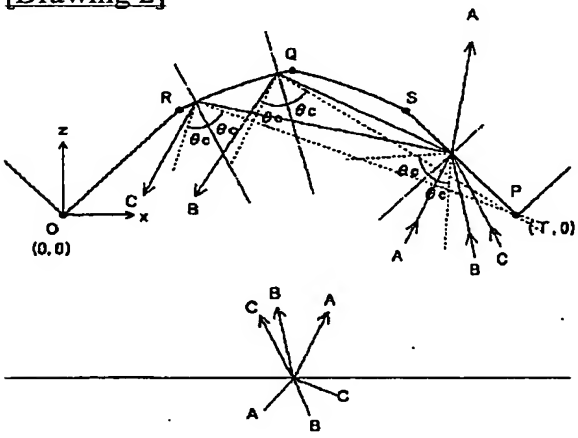
DRAWINGS

[Drawing 1]



[Drawing 2]



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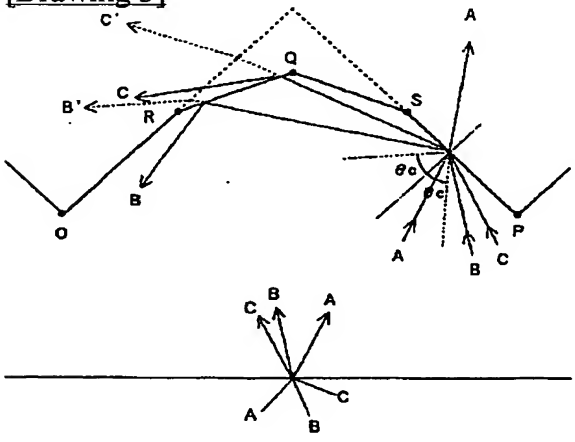
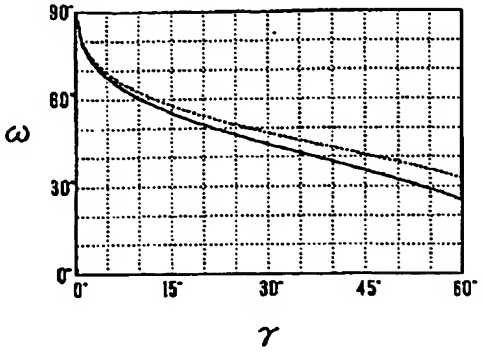
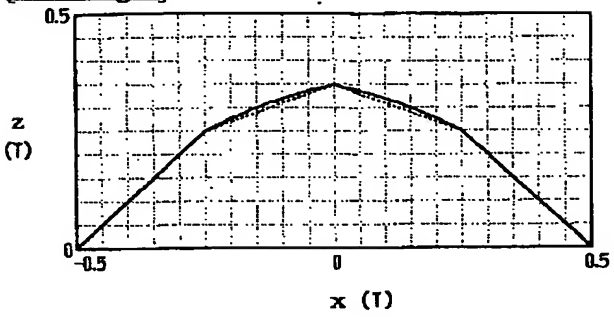


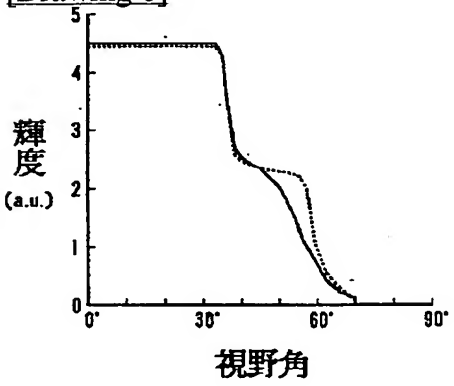
[Drawing 4]



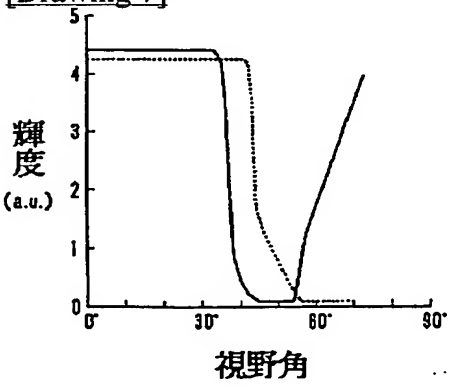
[Drawing 5]



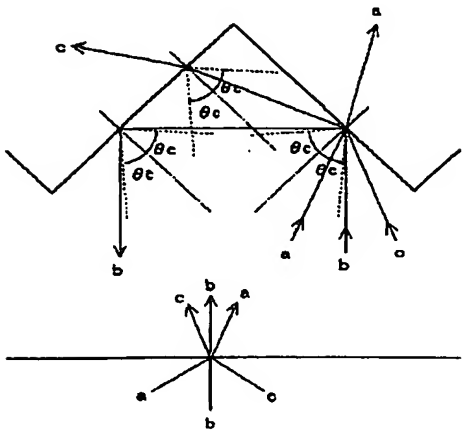
[Drawing 6]



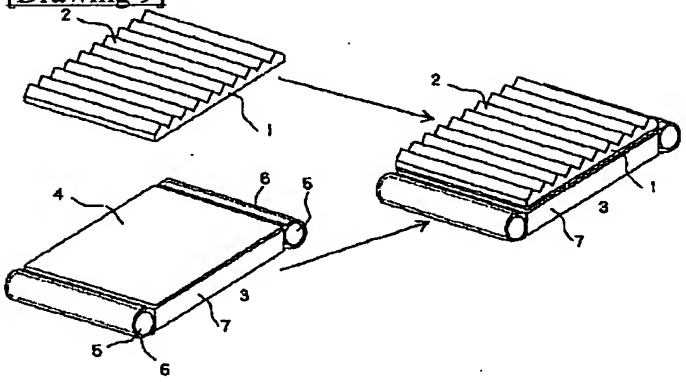
[Drawing 7]



[Drawing 8]



[Drawing 9]



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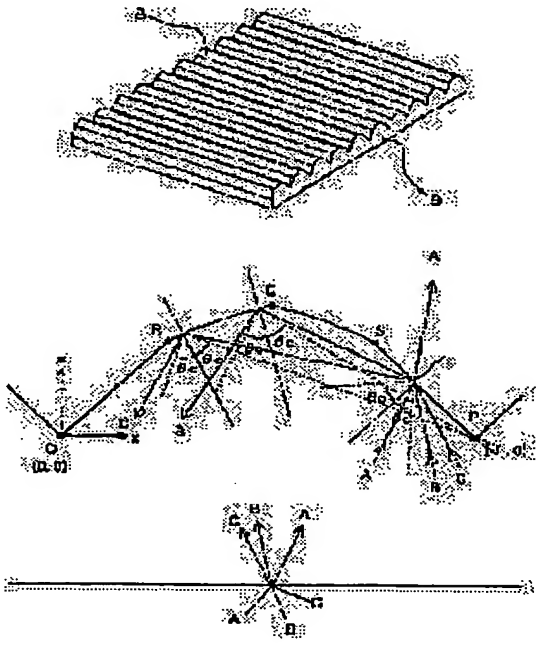
PURPOSE: To obtain a directional back light which has its directivity improved and is usable for a liquid crystal panel with a wide visual field angle without spoiling the front luminance improvement effect by dividing both slanting surfaces of a conventional prism sheet into two and altering the surfaces containing the vertical angle into gentry slanting convex curved columnar surfaces.

CONSTITUTION: The transparent sheet 9 is formed by arraying many shape units 8, each formed by connecting two convex curved columnar surfaces having generating lines parallel to each other in right-left symmetrical relation at right angles to the generating lines, on one surface, and the respective tangential surfaces and planes cross each other at a ≤180° angle. This transparent sheet 9 transmits or reflects the majority of light as primary transmitted light shown by A or return light shown by B and C, and on secondary transmitted light exits, specially, from a curved columnar surface RQS. A little secondary transmitted light exits from oblique surfaces OR and PS, but the majority of the secondary transmitted light falls on an adjacent shape unit 8 and is absorbed under specific conditions, and part of it is added to the return light. Consequently, almost no light exits at a wide angle.



LEGAL STATUS

[Date of request for examination] 24.07.1997

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number] 3106050

[Date of registration] 01.09.2000

[Number of appeal against examiner's decision

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（A）　(11)特許出願公開番号

特開平7－230002

(43)公開日　平成７年(1995) ８月29日

(51)Int.Cl.⁶		識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｇ０２Ｂ	5/02		C		
	5/04		A		
Ｇ０２Ｆ	1/1335	５３０			

審査請求　未請求　請求項の数３　ＯＬ　（全 ７ 頁）

(21)出願番号　特願平6－20669

(22)出願日　平成６年(1994) ２月17日

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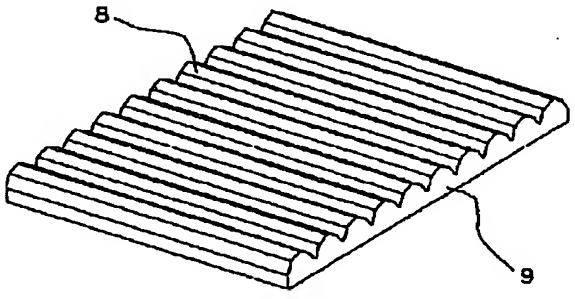
(54)【発明の名称】　輝度向上透明シート

(57)【要約】

【構成】　一方の面に、互いに母線が平行である二つの凸の曲柱面が左右対称に結合した形状単位８が、母線と垂直な方向に多数並んで形成された透明シート９であって、各接面及び平面が180°より小さい角度で交わる形状をなしている。

【効果】　指向特性を改善し、その正面輝度改善効果を損なうことなく広視野角の液晶パネルに使用可能な指向性を有するバックライトを実現することを可能にした。



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【特許請求の範囲】

【請求項１】一方の面に、互いに母線が平行である二つの凸の曲柱面とそれぞれにつながる平面が左右対称に結合した形状単位が、該母線と垂直な方向に多数並んで形成された透明シートであって、該両曲柱面の結合部および各曲面と各平面の結合部では、各接面および平面が180°より小さい角度で交わる形状をなしていることを特徴＊

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＊とする透明シート。

【請求項２】上記透明シートの法線に平行にｚ軸をとり、凸の曲柱面の母線に平行にｙ軸をとり、形成単位の列方向にｘ軸をとるとき、該形成単位の形状が以下の式（１）を満たすように形成されていることを特徴とする請求項１の透明シート。

【数１】

$$z = Ax \quad (0 \leqq x \leqq B)$$

$$\frac{dz}{dx} = \frac{z\tan\phi + (x-p)}{(x-p)\tan\phi - z} \quad (B < x < T/2)$$

$$\frac{dz}{dx} = \frac{z\tan\phi + (T-x-p)}{(T-x-p)\tan\phi - z} \quad (T/2 < x < T-B)$$

$$z = -A(x-T) \quad (T-B \leqq x \leqq T) \qquad \cdots (1)$$

（式中、$\phi = 0.8\theta c \sim 1.2\theta c$，$\theta c = \sin^{-1}(1/n)$，ｎは形成単位の屈折率を表す。ｐ＝0.8Ｔ～1.5Ｔ，Ｔは形成単位の幅を表す。）

【請求項３】一方の面に、四つの平面が左右対称に結合した部分多角柱面が、該多角柱面の母線と垂直な方向に多数並んで形成された透明シートであって、該多角柱面の隣合う面はそれぞれ180°より小さい角度で交わる形状をなしていることを特徴とする透明シート。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、液晶表示装置などに使われるバックライトユニットの正面輝度を、光学的な手段によって向上させる技術に関する。

【０００２】

【従来の技術】近年カラー液晶表示装置を備えた携帯用ノートパソコンや、カラー液晶パネルを使った携帯用液晶ＴＶあるいはビデオ一体型液晶ＴＶなどのバッテリー駆動を前提とした製品において、消費電力が大きい液晶表示装置がバッテリー駆動時間を伸ばすための障害になっている。中でもこれに使われているバックライトの消費電力の割合は大きく、これを低く抑えることがバッテリー駆動時間を伸ばし、上記商品の実用価値を高めるｔで重要な目標とされている。

【０００３】この際、消費電力を抑えるためにバックライトの輝度を低下させたのでは表示が見にくくなって好ましくない。そこで輝度を犠牲にすることなく消費電力を抑えるために、バックライトの光学的な効率を改善することが望まれているが、これを実現する手段として、図９のごとく片面にプリズム列２を形成したプリズムシート１をバックライト３の発光面４の上におく方法が、現在実用化されている。このプリズムシートによる正面輝度の増加は次のようなメカニズムによって引き起こされる。

【０００４】面光源からの光はプリズムシートでその一部が屈折透過し、残りが反射して面光源に戻される。図９の３のようなエッジライト式の面光源は一般的に正面輝度が比較的低く、斜め方向から見た輝度が高い指向性を持っているため、プリズムシート１による屈折で正面輝度が増加するように指向特性が改善される。またプリズムシート１からの反射光は面光源の発光面の拡散シート４で拡散反射され、発光面の輝度を増加させるが、これに伴って正面輝度も増加する。

【０００５】

【発明が解決しようとする課題】図８はこのようなプリズムシートのプリズムの両斜面に垂直な断面を示したもので、入射した光線はその入射角によって、直接プリズム斜面を透過する成分ａ（以後一次透過光と記す）、いったんプリズム斜面で反射した後もう一方の斜面で再び反射して入射側に戻される成分ｂ（以後戻り光と記す）、いったんプリズム斜面で反射した後もう一方の斜面を透過して前に出る成分ｃ（以後二次透過光と記す）におおよそ分けられる（プリズム頂角の選択によってはさらに多重反射する成分も存在するが、その割合は通常少ない）。このとき成分ａは正面すなわち観測する方向に出る光を含む実際に利用される光線であり、また成分ｂは面光源の発光面の拡散シートで拡散反射され、発光面の輝度を増加させる有効な光線である。これに対して成分ｃは液晶パネルの有効な視野角外の広角度に出る光線であり、役に立たない成分である。

【０００６】この結果プリズムシートからの光はプリズムの稜線に垂直な方向について、正面から±40°前後の視野角（頂角90°～100°，屈折率1.5～1.59程度の場合）の幅に明るい光（一次透過光）を放ち、それ以上の視野角になると輝度は急激に低下し、いったんほとんどゼロになってから更に大きな視野角で再び輝度が増加する（二次透過光）。結果的に出射光線の角度範囲を絞って明るさを増した形になっている。

【０００７】ここで問題になるのは、第一に40°前後の視野角以上において輝度が急激に低下する指向性である。近年液晶パネルの指向性は改善が進み、指向性が狭い方向においても40°以上の視野角で十分実用的なコントラストを示すものが開発されている。このような液晶パネルには視野角の増加に伴う輝度の低下が緩やかで、ある程度広い指向性を示すことが望まれている。

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【0008】また第二の問題点は役に立たない二次透過光の存在であり、この成分を減らすことができればより一層の効率改善が期待できる。このためにはUSP2,474,317に指摘されているようにプリズムの頂角を

【0009】

【数2】

$180°-4(90°-\theta c)/m$, (mは3以上の整数) ・・・(2)

【0010】に選択することが考えられる。これによって二次透過光はゼロになり、全体としての効率は改善されるが依然として上記した第一の問題点は残る。

【0011】本発明の目的は正面方向に最も高い輝度を示し、所定の視野角を越えた方向には視野角の増加に伴って緩やかに低下する輝度分布を持ち、且つ上記した二次透過光の発生を抑えた高効率の輝度増加効果を持つ光学シートを開発することである。

【0012】

$$z = Ax$$

$$\frac{dz}{dx} = \frac{z\tan\phi + (x-p)}{(x-p)\tan\phi - z}$$

$$-\frac{dz}{dx} = \frac{z\tan\phi + (T-x-p)}{(T-x-p)\tan\phi - z} \quad (T/2 < x < T-B)$$

$$z = -A(x-T) \quad (T-B \leqq x \leqq T)$$

【0015】なおここで$\phi = 0.8\theta c \sim 1.2\theta c$, $\theta c = \sin^{-1}(1/n)$, nは形成単位の屈折率を表す。また$p = 0.8T \sim 1.5T$, Tは形成単位の幅を表す。

【0016】さらに本発明請求項3は一方の面に、四つの平面が左右対称に結合した部分多角柱面が、該多角柱面の母線と垂直な方向に多数並んで形成された透明シートであって、該多角柱面の隣合う面はそれぞれ180°より小さい角度で交わる形状をなしていることを特徴とする透明シートである。

【0017】

【作用】以下本発明の作用を図を使って説明する。図2は本発明請求項2の透明シートのxz断面図であり、(1)式の$\phi = \theta c$, $p = T$である最も特徴的でかつ本設計の意図を説明するのに適した場合を表している。ここでOR, PS間は平面であり、その機能は図8のプリズムシートの斜面と同様である。式で表せば以下のようになる。

【0018】

【数4】$z = Ax$ $(0 \leqq x \leqq B$：OR間)

$z = -A(x-T)$ $(T-B \leqq x \leqq T$：PS間)

【0019】一方RQ, SQ間は本発明によって導入された曲柱面である。図8の従来のプリズムシートにおいて、二次透過光はそのほとんどがプリズムの頂角付近から発しているから、これを発生させない為には頂角付近の形状を変えて、対向する斜面で反射した光がすべてこの部分で全反射するようにすればよい。このために図2の透明シートでは頂角付近のRQ, SQ間を凸の曲柱面とし、対向する斜面からこの部分に達する光が常に全反

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*【課題を解決するための手段】本発明請求項1の透明シートは、一方の面に、互いに母線が平行である二つの凸の曲柱面とそれぞれにつながる平面が左右対称に結合した形状単位が、該母線と垂直な方向に多数並んで形成された透明シートであって、該両曲柱面の結合部および左右各曲柱面と各平面の結合部では、各接面および平面が180°より小さい角度で交わる形状をなしていることを特徴とする透明シートである。

【0013】また本発明請求項2の透明シートは、上記透明シートの法線に平行にz軸をとり、凸の曲柱面の母線に平行にy軸をとり、形成単位の列方向にx軸をとるとき、該形成単位の形状が以下の式(1)を満たすように形成されていることを特徴とする請求項1の透明シートである。

【0014】

* 【数3】

$$\left.\begin{array}{ll} (0 \leqq x \leqq B) & \\ (B < x < T/2) & \\ (T/2 < x < T-B) & \\ (T-B \leqq x \leqq T) & \end{array}\right\} \quad \cdots \quad (1)$$

射角$\theta c = \sin^{-1}(1/n)$以上の入射角でこの部分に入射するようにしてある。RQ間の各点から見たとき最も小さな入射角で入射する光線は点Pからの反射光であるから、PからRQ間の各点を結んだ直線が同点における面の法線となす角がθcと等しくなるように選べば、右斜面の他の点からの反射光は全てRQ間で反射することになる。このとき点Oを原点にとると、点Pの座標は(T, 0)となり、曲柱面RQの満たす条件は

【0020】

【数5】

$$\frac{dz}{dx} = \frac{z\tan\theta c + (x-T)}{(x-T)\tan\theta c - z} \quad (B < x < T/2)$$

【0021】となる。実際には平面部ORと点Rで一致する境界条件のもとにこの式を数値積分してRQの形が決定される。SQ間についても同様であり、$x = T/2$を中心に左右対称の形状になる。このようにして一つの形状単位ORQSPの全体は(1)式で表されることになる。

【0022】このように図2の断面形状の透明シートでは、ほとんどの光がAのような一次透過光になるかB, Cのように戻り光になり、特に曲柱面RQSからは二次透過光が出ることはない。斜面OR及びPSからは若干の二次透過光が出るが、(1)式のBを適当に選べばほとんどの二次透過光は隣の形状単位にぶつかって吸収され、その一部が戻り光に加わる。結果として図8のcのような広角度に出る光はほとんどなくなることになる。

【0023】本透明シートの形状単位の平面部OR, PSの機能は従来のプリズムシートの斜面と同等であるた

め、ここからの一次透過光は従来のプリズムシートと同等な指向性を示すが、曲柱面ＲＱＳの傾斜は平面部より緩く且つ曲面であることにより、この部分からの一次透過光は平面部ＯＲ，ＰＳのそれより広く且つ輝度が徐々に角度変化する指向性を持っている。この結果本透明シートは従来のプリズムシートの視野角を越えても急激に輝度が低下するようなことがなく、輝度－角度曲線に肩を作りつつ徐々にゼロに近づく指向性を示すことになる。

【００２４】以上は(1)式の$\phi=\theta c$，ｐ＝Ｔの場合について説明したが、ϕ，ｐの値を調節することによって得られる特性を若干変化させることが可能である。例えば$\phi>\theta c$あるいはｐ＜Ｔとすれば形成単位の曲柱面ＲＱＳの傾斜は一様に緩くなり、より視野角が広げられる。従って特に広い視野角を必要とする場合に有効である。この場合にも二次透過光は生じないが、視野角を広げたことによって正面輝度の増加率は$\phi=\theta c$，ｐ＝Ｔの場合に比べて低下する。正面輝度の増加率があまり低くなると透明シートのメリットが薄くなるためϕは大きくても$1.2\theta c$程度まで、ｐは小さくとも0.8Ｔ程度までとするのが好ましい。

【００２５】一方、$\phi<\theta c$あるいはｐ＞Ｔとすれば視野角は狭まり、正面輝度の増加率をより高めることが期待できる。この場合には二次透過光を生じることになるが、ϕの減少あるいはｐの増加が僅かであれば大きな問題にならない。しかしながらｐをあまり大きく取ったり、ϕを小さくし過ぎたりすると二次透過光が増加して正面輝度の低下を招くため好ましくない。ϕは小さくとも$0.8\theta c$程度まで、ｐは大きくとも1.5Ｔ程度までとするのが好ましい。

【００２６】上記した透明シートにおいて(1)式のＡすなわち平面部分ＯＲ，ＰＳの傾斜は輝度が最も高い視野角範囲を決定するもので、この視野角をωとおくとωは以下の式で表される。

【００２７】

【数６】$\omega=\gamma+\sin^{-1}(n\sin^{-1}(\theta c-\gamma))$　但し$\gamma=\tan^{-1}A$

【００２８】屈折率1.59（ポリカーボネート），1.49（ポリメチルメタクリレート）の場合のγとωの関係を図４に示した。γを小さくすればωは大きくなり視野角は広くなるがあまり小さくすると輝度の改善効果が薄れて好ましくない。またあまり視野角を狭くすることは実用上好ましくなく、結果としてγは35°～55°の範囲で選択することが好ましく、特に40°～50°の間が最も実用的である。なお上述したように本発明の透明シートはωを越えた角度において輝度は低下するものの、曲柱面部ＲＱＳからの一次透過光によって低下の度合いは緩やかであり、実用的な視野角はω以上に広がっている。

【００２９】また(1)式のＢは、形成単位における平面部分と曲柱面部分の比率を決定している。Ｂはあまり大きくすると従来のプリズムシートに近くなり、本発明の効果が薄れて好ましくなく、また小さくすれば視野角は改善されるが、あまり小さくすると輝度の改善効果が低下して好ましくない。Ｂは0.2Ｔ～0.35Ｔの範囲で選択するのが実用的に好ましい。

【００３０】以上のように(1)式で示される断面形状の形成単位の列を片面に持つ透明シートは、なだらかな輝度変化を示す指向特性と、二次透過光を抑えることによる効率向上を同時に実現できることがわかる。しかしながらこの効果は曲柱面ＲＱ，ＳＱの断面形状が(1)式で表される場合に必ずしも限るものではなく。効果の大きさに違いはあるものの、その形状が凸の曲柱面であって傾斜の絶対値が平面部ＯＲ，ＰＳより小さいものであれば他の関数形（円柱面、二次の曲柱面など）でも、図２のごとき作用や輝度の角度変化を緩める作用をもっている（請求項１）。

【００３１】さらにＲＱ，ＳＱは請求項３のように平面であっても、その傾斜の絶対値がＯＲ，ＰＳより小さければ同様の作用を持つ。図３は図２のＲＱ，ＳＱ間を平面に置き換えたものであるが、図中に点線で示した従来のプリズム形状ではＢ’のように二次透過光となる一部の光が平面ＲＱで反射して戻り光Ｂとなり、同様に従来のプリズム形状でＣ’のように広角度に向かう二次透過光の一部がＣのように平面ＲＱでより大きく曲げられて隣の形成単位に入り、この一部が戻り光となる。ＲＱ，ＳＱ間の傾斜を更に小さくすれば二次透過光をゼロにすることも可能である。但しこれらの場合の輝度角度分布は請求項１，請求項２の透明シート程緩やかなものではなく、平面部ＯＲ，ＰＳからの一次透過光が作る比較的狭い角度分布とＲＱ，ＳＱ間の一次透過光が作る比較的広い角度分布の重ね合わせによって段階的に変化する特徴的なものとなる。

【００３２】本発明請求項１および請求項２の透明シートの斜視図を図１に示した。実際のシートの厚さは0.1ｍｍ～3ｍｍ程度、形成単位のピッチＴは30μｍ～0.5ｍｍ程度である。本透明シートは図９のプリズムシート１に置き換えて使われる。また本発明の透明シートをその形成単位直交させて二枚重ねて使えばさらに正面輝度は改善される。

【００３３】

【実施例】屈折率1.59（ポリカーボネート）について、$\phi=\theta c$，ｐ＝Ｔ，Ａ＝１（傾斜45°），Ｂ＝Ｔ/4のときの請求項２の形成単位の形状を求めたものを図５に実線で示した。これは(1)式から数値積分によって容易に計算できる。これをもとにＴ＝50μｍとして同図と相似形の断面形状の溝を並べた金型を製作し、厚さ２ｍｍのポリカーボネート透明板に熱プレスして請求項２の透明シートを製作した。さらにこの透明シートをエッジライト式面光源の発光面に重ね、輝度の角度分布を測定し、この結果を図８に実線で示した。このときの正面輝度増加率

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は1.55倍であった。

【００３４】また図５の点線のごとく各頂点を直線で結んだ断面形状で、同様にＴ＝50μｍとして同図と相似形の断面形状の溝を並べた金型を製作し、厚さ２㎜のポリカーボネート透明板に熱プレスして請求項３の透明シートを製作した。この透明シートについて先と同様に輝度の角度分布を測定した結果を図８に点線で示した。このときの正面輝度増加率は1.54倍であった。

【００３５】比較例として頂角90°および112°のプリズムを50μｍピッチで並べた形の金型を製作し、厚さ２㎜のポリカーボネート透明板に熱プレスして従来のプリズムシートを製作した。ここで頂角112°は(2)式においてｍ＝３とおいたものである。この透明シートを先ほどと同じ面光源の発光面に重ね、輝度の角度分布を測定した。この結果を図７にそれぞれ実線と点線で示した。このときの正面輝度増加率は頂角90°の場合で1.52倍、頂角112°の場合で1.46倍であった。

【００３６】図６と図７を比較すれば明らかなように、本発明の透明シートは従来のプリズムシートに遜色ない正面輝度増加率を持ちながら、視野角の増加に伴って徐々に輝度が低下するという従来のプリズムシートにない特徴を持ち、広視野角の液晶パネルの性能を生かす指向性を実現していることが分かる。また図６の実線と点線の比較から分かるように、より滑らかな輝度分布を実現するためには曲柱面を導入した請求項２の透明シートのほうがより好ましいが、金型製作の簡便さは請求項３の方が勝っており、性能とコストのいずれをより重視するかによってどちらかを選択すれば良い。

【００３７】

【発明の効果】本発明の透明シートは従来のプリズムシートの両斜面をそれぞれ二分割し、このうち頂角をなす面を傾斜の緩い凸の曲柱面（請求項１、請求項２）或いは平面（請求項３）に変えることによって指向特性を改善し、その正面輝度改善効果を損なうことなく広視野角の液晶パネルに使用可能な指向性を有するバックライトを実現することを可能にした。

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【図面の簡単な説明】

【図１】本発明の透明シートの斜視図である。

【図２】本発明の透明シートの作用を説明する断面図である。

【図３】本発明の透明シートの作用を説明する断面図である。

【図４】プリズムシートの斜面の傾斜と視野角の関係を表すグラフである。

【図５】本発明の透明シートの片面に形成される形成単位の設計例の断面図である。

【図６】実施例の透明シートを使ったバックライトの輝度の角度変化を示すグラフである。

【図７】比較例のプリズムシートを使ったバックライトの輝度の角度変化を示すグラフである。

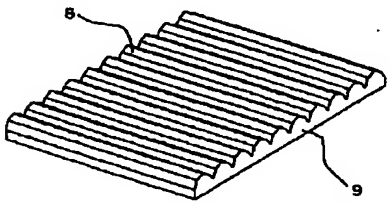
【図８】従来のプリズムシートの作用を説明する断面図である。

【図９】従来のプリズムシートの使用される形態を示す斜視図である。

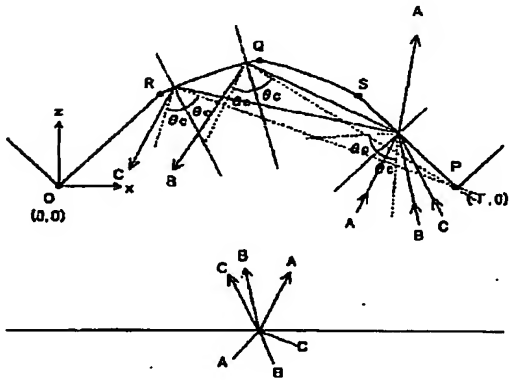
【符号の説明】

１　・・・プリズムシート
２　・・・プリズム列
３　・・・バックライト
４　・・・拡散フィルム
５　・・・冷陰極管
６　・・・反射フィルム
７　・・・導光体
８　・・・透明シート表面の形成単位
９　・・・本発明の透明シート

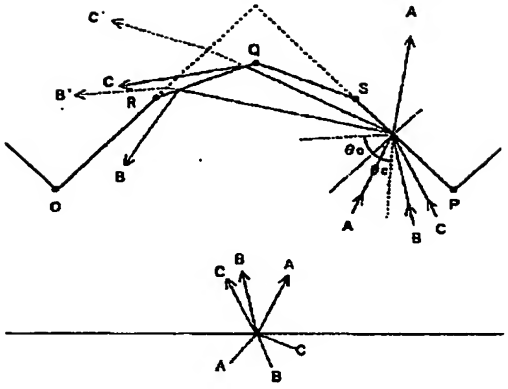
【図１】



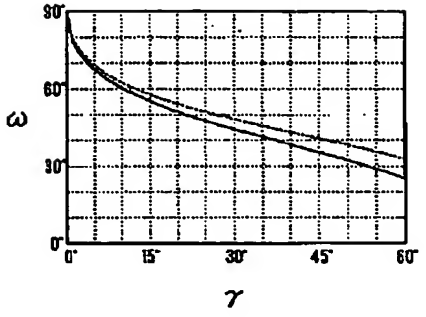
【図２】



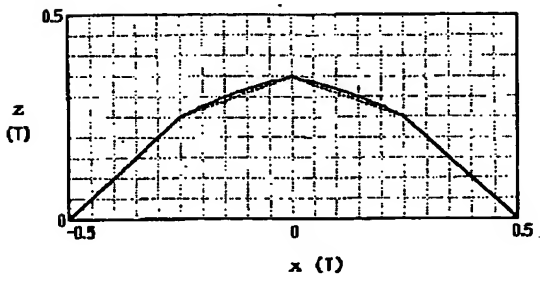
【図３】



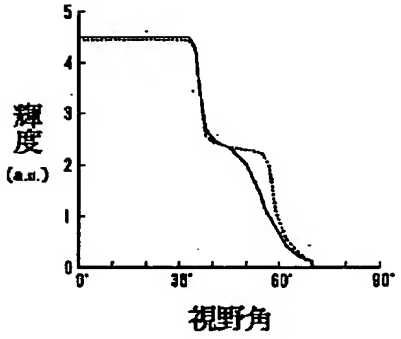
【図４】



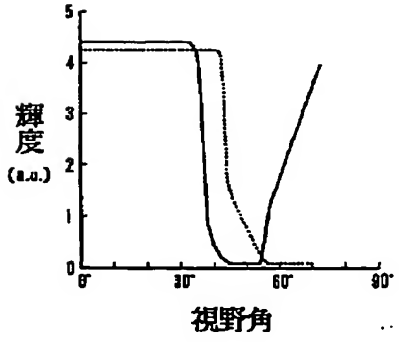
【図５】



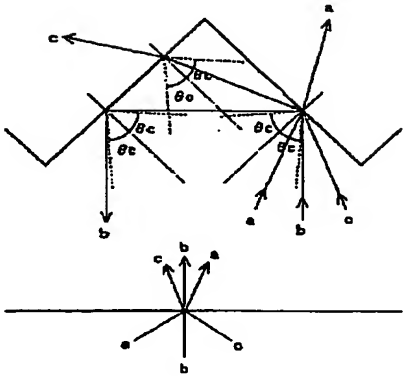
【図６】



【図７】



【図８】



【図9】